

# Three new species of *Paryphantopsis* (Gastropoda: Pulmonata: Charopidae) from the Nakanai Mountains, New Britain, Papua New Guinea

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## ABSTRACT

Recent surveys (February–March, 2005) of the terrestrial snail fauna of the Nakanai Mountains, central New Britain, Bismarck Archipelago have uncovered several undescribed species, including three new species of *Paryphantopsis*, a diverse genus of charopid snails, previously believed to be endemic to mainland New Guinea and adjacent islands of the Louisiade Archipelago. The three species are described using shell, genital, and radular morphology. Although the land snail fauna of New Britain is arguably the best sampled in Papua New Guinea, there has been little sampling in the interior mountains of the Nakanai, Whiteman, Baining, and Willanmez ranges, which harbor previously undetected species of terrestrial snails.

*Additional Keywords:* Pulmonata, Charopidae, *Paryphantopsis*, New Britain, Papua New Guinea

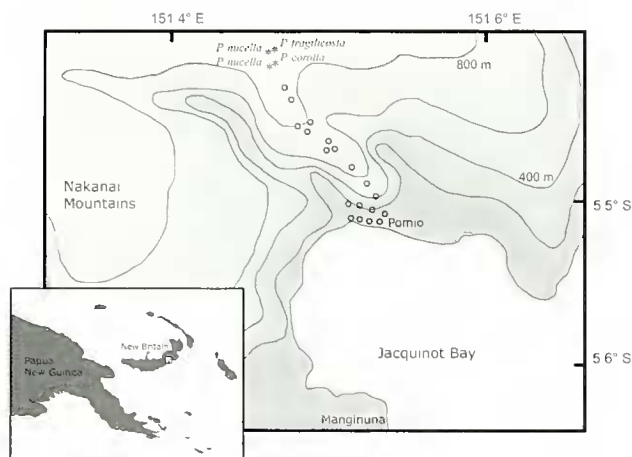
## INTRODUCTION

This is the third in a series of reports on the results of recent field surveys for terrestrial mollusks from Papua New Guinea. The previous two reports focused on species of *Paryphantopsis* from the eastern peninsula of mainland New Guinea (Slapcinsky, 2005) and nearby islands of the Louisiade Archipelago (Slapcinsky, 2006). This report reviews *Paryphantopsis* species collected during three weeks of field surveys in February and March 2005 from the Nakanai Mountains northwest of Pomio, East New Britain Province, Papua New Guinea (Figure 1). *Paryphantopsis*, a diverse genus of charopid snails endemic to New Guinea and surrounding islands, is comprised of 23 described species (Solem, 1970; Slapcinsky, 2005; Slapcinsky, 2006) that are distributed from Papua (Irian Jaya) to the Louisiade Archipelago and that, prior to this study, were not known from New Britain.

Nearly all species of *Paryphantopsis* have distributions restricted to single mountain ranges or islands where

they are found in hilly or mountainous terrain from 60 to 4000 meters elevation. In upland habitats they can be the most abundant snail species reaching densities of more than 10 individuals per square meter on Sudest and Rossel Islands in the Louisiade Archipelago (personal observation). Despite their small size (4–12 mm), their bright yellow body coloration and diurnal activity in exposed locations on tree trunks, vegetation and rotting wood make them among the most obvious snail species. These showy snails are under-sampled and recent surveys have nearly doubled the number of recognized species. Further sampling in New Guinea and surrounding islands will certainly uncover additional species of *Paryphantopsis* as well as many other more cryptic snail species.

New Britain, a large volcanic island, 35145 km<sup>2</sup>, extending from 148° to 152° E longitude and from 4° to 7° S latitude, emerged in the late Miocene (8–10 mya). The island's basement rocks were deposited by volcanic activity, between the upper Eocene and the middle Oligocene. Volcanic activity ceased in the early Miocene leading to regional subsidence and the deposition of extensive reef complexes. At the end of the Miocene, subduction of the Solomon plate under the Bismarck plate led to renewed volcanism, resulting in a chain of young arc volcanoes along the northwestern coast of New Britain (Woodhead et al. 1998). At the same time, reef complexes along the south and eastern coasts of the island were rapidly uplifted, creating extensive karst mountains. One of these ranges, the Nakanai Mountains, contains the Southern Hemisphere's deepest caves, some nearly 1200 meters in depth (Audra et al. 2001). New Britain's isolation, complex geology, and extensive raised limestone have allowed the radiation of a diverse and largely endemic land snail fauna (Rensch, 1934; 1937) that is among the best surveyed in Papua New Guinea. However, rough karst terrain and lack of roads have limited nearly all surveys to coastal lowlands, and most taxa from interior mountains of the Nakanai, Whiteman, Baining, and Willanmez ranges are still poorly surveyed (Boehler,



**Figure 1.** Distribution of *Paryphantopsis* in New Britain, Papua New Guinea; o = other sites sampled.

1993), even for macrofauna such as mammals (Flannary, 1995: 12) and birds (Orenstein, 1976). The invertebrate fauna of New Britain's interior mountains is almost entirely unknown. This is disturbing because intensifying land usage, including logging and the establishment of oil palm plantations (McAlpine and Fryne, 2001), threatens to deforest extensive areas of New Britain before they can be adequately inventoried, potentially leading to largely undocumented losses in biodiversity.

**MATERIALS AND METHODS**

Specimens were hand-collected, drowned overnight, and then preserved in 75% ethanol. Gross anatomical dissections were made under 75% ethanol using a dissecting microscope. Radulae were isolated from dissected buccal masses using 5% sodium hypochlorite solution. Scanning electron micrographs of radulae were made using a Field Emission SEM. Line drawings of the genital anatomy were made from digital images, and measurements were taken using an ocular micrometer. Shell measurements were made as figured in Slapcinsky (2005). The following abbreviations are used in figures of genital anatomy: AT = atrium, DI = diverticulum, EP = epiphallus, OV = free oviduct, PE = penis, PG = prostate gland, PP = penial

pilasters, PR = penial retractor muscle, SD = spermathecal duct, SP = spermatheca, VA = vagina, VD = vas deferens. Terminology of vegetation types follows Paijmans (1976). Specimens are deposited in the following institutions: Bernice P. Bishop Museum, Honolulu (BPBM); Florida Museum of Natural History, Gainesville (UF); Natur-Museum Senckenberg, Frankfurt (SMF); Papua New Guinea National Museum, Port Moresby (PNGNM); Wroclaw University Museum of Natural History (MNHW).

**SYSTEMATICS**

Family Charopidae Hutton, 1854  
Genus *Paryphantopsis* Thiele, 1928

**Type Species:** *Flammulina (Paryphantopsis) lamelligera* Thiele, 1928, by original designation.

*Paryphantopsis corolla* new species  
(Figures 2–7, Table 1)

**Holotype:** UF 36650S, J. Slapcinsky, 25 February 2005.

**Paratype:** UF 366453 (1 specimen), J. Slapcinsky, 25 February 2005.

**Type Locality:** Papua New Guinea, East New Britain Province, New Britain, 12 km northwest of Marmar Village on the trail to Pakia Village, 5.432° S, 151.460° E, 900 meters altitude (Figure 1).

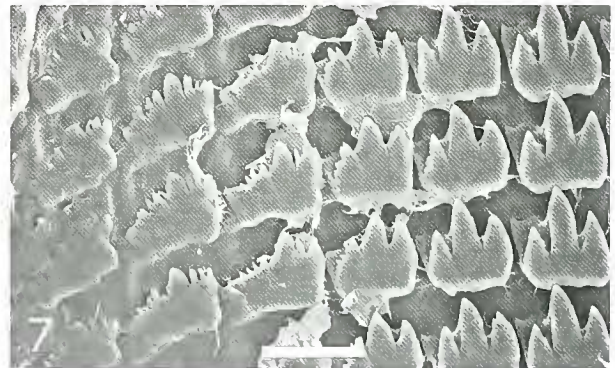
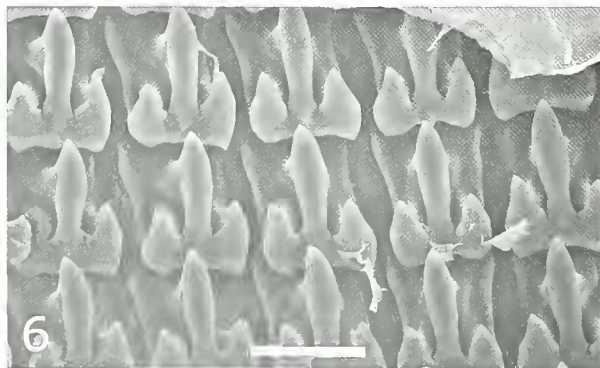
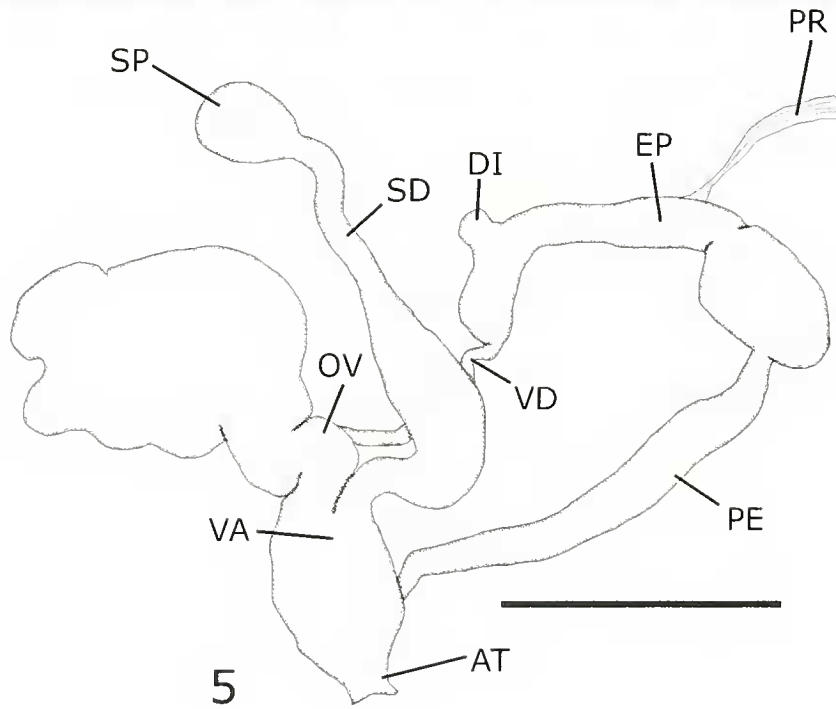
**Habitat:** Collected in mixed hill forest on vegetation within 1 m of the ground.

**Description:** The adult shell is depressed-globose, small for the genus, 3.5–3.6 mm (mean = 3.55, see Table 1 for sample size and standard deviation) in diameter and 2.2–2.3 mm (mean = 2.25) in height, with 2.5–2.6 (mean = 2.55) rapidly expanding whorls (Figures 2–4). The apical surface of the whorls flattens between the deep suture and the shell periphery which is slightly angular a little above its mid-point. The basal surface of the whorl is evenly rounded from the angular periphery to the umbilicus. The spire is slightly elevated, 0.1–0.2 mm (mean = 0.15). Teleoconch whorls descend slowly and regularly and shell height/diameter ratio is 0.61–0.66 (mean = 0.63). Approximately 1.3 rounded protoconch whorls are sculptured with 13 rows of spiral

**Table 1.** Measurements in mm of undamaged adult shells of three species of *Paryphantopsis*.

Species	N		H	D	SH	SD	AH	AW	W
<i>P. corolla</i>	2	Mean ± SD	2.25 ± 0.07	3.55 ± 0.07	0.15 ± 0.07	1.60 ± 0.00	1.60 ± 0.00	2.15 ± 0.07	2.55 ± 0.07
		Range	2.2–2.3	3.5–3.6	0.1–0.2	1.6–1.6	1.6–1.6	2.1–2.2	2.5–2.6
<i>P. fragilicosta</i>	6	Mean ± SD	3.43 ± 0.18	5.00 ± 0.20	0.13 ± 0.05	2.33 ± 0.12	2.45 ± 0.16	2.92 ± 0.16	3.00 ± 0.09
		Range	3.2–3.7	4.8–5.3	0.1–0.2	2.2–2.4	2.3–2.7	2.8–3.2	2.9–3.1
<i>P. nucella</i>	10	Mean ± SD	3.75 ± 0.32	5.22 ± 0.23	0.15 ± 0.04	2.06 ± 0.20	2.75 ± 0.27	3.16 ± 0.22	2.81 ± 0.12
		Range	3.3–4.1	4.9–5.7	0.1–0.2	1.8–2.5	2.4–3.3	2.9–3.6	2.6–3.0

N = number of specimens. H = height. D = diameter. SH = spire height, SD = spire diameter, AH = aperture height. AW = aperture width. W = number of whorls.



Figures 2-7. *Paryphantopsis corolla*. 2-4. Shell, Holotype UF 366505. Scale bar = 1 mm; Figure 5. Genitalia, UF 366453. Scale bar = 1 mm. 6-7. SEMs of radula, UF 366453. 6. Central and lateral teeth. 7. Marginal teeth. Scale bars = 10 µm.



pits, which continue on the teleoconch where the pits elongate nearly fusing to form incised spiral lines. These apical pits are typical of nearly all species of *Paryphantopsis* as, for example, in *Paryphantopsis louisadarum* (see Solem, 1959: plate 13, fig 6). Approximately every third growth line is accentuated with a periostracal extension that bears a sharply pointed triangular process at the shell periphery. These processes are approximately 0.2 mm in length and 0.3 as wide at the base. The protoconch and teleoconch whorls are uniformly brown except for the columellar edge of the peristome and umbilicus, which are slightly darker brown. A reflection of the peristome covers approximately 0.4 of the umbilicus. The aperture is large and ovate with an aperture:width to aperture:height ratio of 1.31–1.38 mm (mean = 1.34).

The external body color is bright yellow in life and there are no bands or other color patterns. Specimens preserved in ethanol fade to uniform cream. The head is short similar to other species of *Paryphantopsis* and the posterior of the foot is slightly shorter than average for the genus.

The vas deferens is 0.2 the diameter of the head of the epiphallus which bears a short subapical diverticulum approximately 0.1 the length, and 0.6 the diameter of the epiphallus where they join (Figure 5). The apical 0.7 of the epiphallus is uniform in diameter; the basal 0.3 is twice as wide and ovoid. The penial retractor muscle is long and originates at the diaphragm, inserting 0.6 the way to the base of the epiphallus. The penis is approximately the same length as the epiphallus and the same diameter as the apical 0.7 of the epiphallus. The penis, narrow apically, widens slightly below the apex, and tapers basally to 0.2 the diameter of the atrium where they join. The atrium, widest at the insertion of the penis, narrows abruptly by 0.6 at the gonopore. The vagina narrows slightly at the junction with the free oviduct and spermathecal duct. The S-shaped free oviduct is 1.2 times the width of the spermathecal duct at their junction with the vagina. The diameter of the spermathecal duct doubles from its junction with the vagina distally to 0.4 the length, then narrows to 0.4 its greatest diameter at 0.7 the length, and remains narrow to the junction with the ovate spermatheca.

The central teeth of the radula (Figure 6, second from the right) are tricuspid, 7–8  $\mu\text{m}$  wide and 11–12  $\mu\text{m}$  long, of similar shape and length but slightly narrower and shorter than the first laterals, 5–9  $\mu\text{m}$  wide and 12–13  $\mu\text{m}$  long (Figure 6). The mesocones of both the centrals and first laterals are tall and slender, and project beyond their basal plates. The ectocones of the central teeth are trigonal and symmetric. Ectocones and endocones of the laterals are trigonal and about 0.5 the height of the mesocones. The endocones of the laterals are slightly larger but otherwise of similar shape to their ectocones. The first 5 teeth to the left and right of the central row are similar to the first lateral teeth, the next 3 teeth on either side grade in shape and are difficult to classify as either lateral or marginal teeth. The last 4 marginal teeth are wider, 10–11  $\mu\text{m}$  wide, and shorter

7–8  $\mu\text{m}$  long (Figure 7). Both the endocones and ectocones of the marginal teeth are irregularly multicuspid. The endocones are 0.9–0.8 as tall as the mesocones and usually bear 3 cusps, although these are sometimes divided into additional cusps. The ectocones sit on a rectangular base and are divided into 5 or more cusps that are 0.7 to 0.8 the height of the mesocones.

**Remarks:** The only other *Paryphantopsis* species with shells bearing periostracal processes are: *P. abstrusa* Slapcinsky, 2005; *P. fultoni* (Coen, 1922); *P. lebasii* Slapcinsky, 2005; *P. lamelligera* (Thiele, 1928); *P. striata* (Fulton, 1902); *P. yawii* Slapcinsky, 2005; and *P. yelensis* Slapcinsky, 2006. However, the periostracal processes in *P. corolla* do not overlap unlike *P. fultoni* and *P. yawii*, and are sharply pointed unlike *P. lebasii*. Also, the processes are prominent unlike *P. abstrusa* and *P. yelensis*. Finally, the shells of *P. lamelligera* and *P. striata* are more than twice the size of *P. corolla*. *Paryphantopsis corolla* has an epiphallus that is basally robust unlike all other *Paryphantopsis* species for which the genital anatomy is known except for *P. nucella* and *P. misimensis* Slapcinsky, 2006. In contrast to *P. corolla*, *P. nucella* has an apically inflated penis in addition to a large dark glandular area on the spermathecal duct, and *P. misimensis* lacks an apical diverticulum. The ectocones of the marginal teeth sit on a rectangular extension of the tooth, unlike all other *Paryphantopsis* for which the radular morphology is known other than *P. fragilicosta* and *P. nucella*.

**Etymology:** The species name is from the Latin feminine noun *corolla* and describes the shells resemblance to a small garland or crown.

*Paryphantopsis fragilicosta* new species  
(Figures 8–13, Table 1)

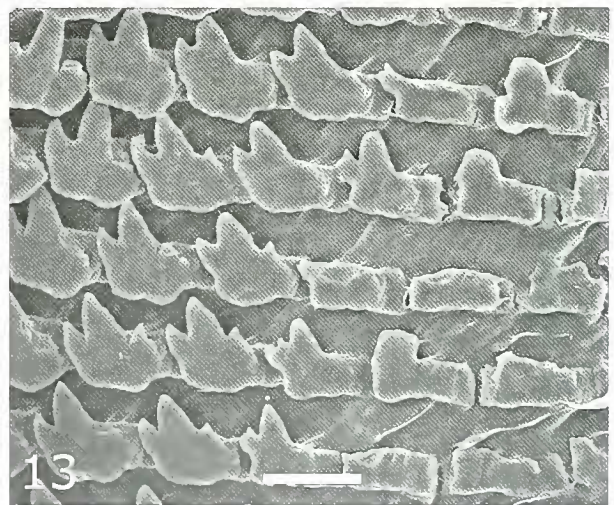
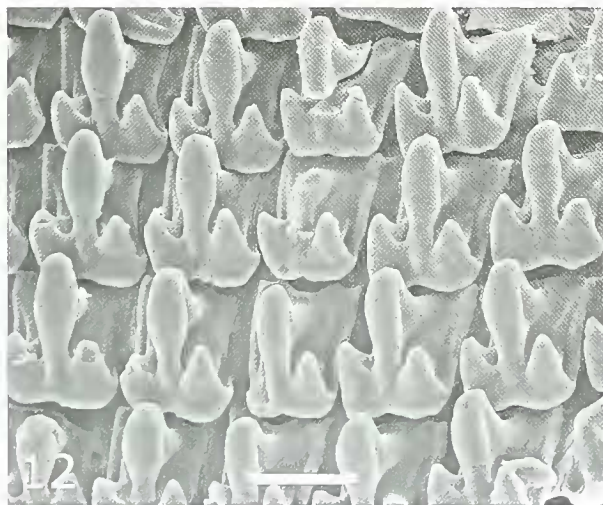
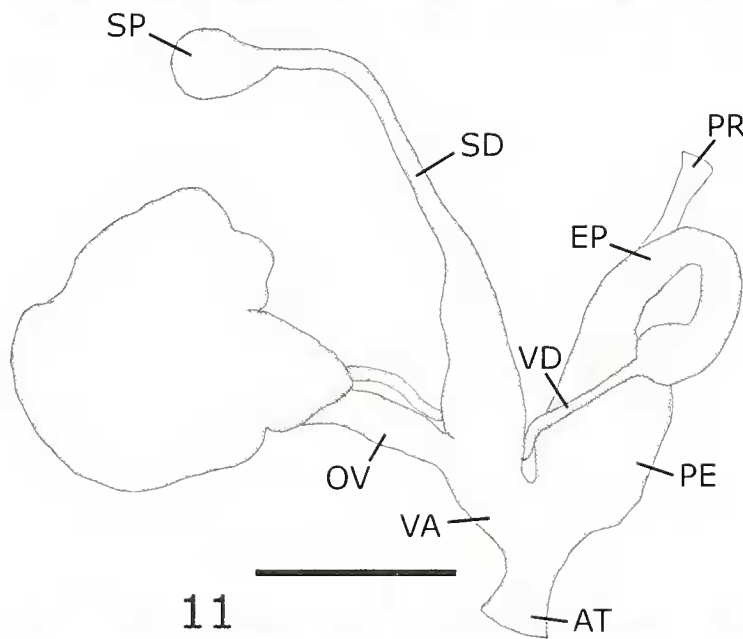
**Holotype:** UF 383995, J. Slapcinsky, 28 February 2005.

**Paratypes:** Papua New Guinea, East New Britain Province, type locality, J. Slapcinsky, 28 February 2005, BPBM 282461 (2 specimens), PNGNM (1 specimen), UF 366505 (4 specimens), UF 366507 (9 specimens).

**Type Locality:** Papua New Guinea, East New Britain Province, New Britain, Sankale, 13 km northwest of Marmar Village on the trail to Pakia Village, 5.426° S, 151.453° E, 910 meters altitude (Figure 1).

**Habitat:** Collected in mixed hill forest on vegetation within 1 meter of the ground.

**Description:** The adult shell is globose to depressed-globose, average size for the genus, 4.8–5.3 mm (mean = 5.00, see Table 1 for sample size and standard deviation) in diameter and 3.2–3.7 mm (mean = 3.13) in height, with 2.9–3.1 (mean = 3.00) rapidly expanding whorls (Figures 8–10). The suture is deeply impressed and the shell periphery is evenly rounded. The spire is slightly elevated, 0.1–0.2 mm (mean = 0.13). Teleoconch whorls descend slowly and regularly until the end of the body whorl, which descends slightly more rapidly. The shell



Figures 8–13. *Paryphantopsis fragilicosta*. 8–10. Shell, Holotype UF 383995. Scale bar = 1 mm. 11. Genitalia, UF 366507. Scale bar = 1 mm. 12–13. SEMs of radula, UF 366507. 12. Central and lateral teeth. 13. Marginal teeth. Scale bars = 10  $\mu$ m.



height:diameter ratio is 0.65–0.71 (mean = 0.69). There are approximately 1.4 evenly rounded protoconch whorls sculptured with 13 spiral rows of small pits which continue on the teleoconch where the pits elongate nearly fusing to form discontinuous spiral striae. Short periostracal extensions that do not bear periostracal processes are present approximately every four growth lines. These extensions are often worn or absent in older adult shells. The protoconch and teleoconch whorls are usually uniformly brown, shiny, and translucent, although older worn shells can be dull brown, opaque, with a white protoconch. The umbilicus is closed or nearly closed by a reflection of the peristome. The aperture is large and ovate, with an aperture:width to aperture:height ratio of 1.08–1.28 (mean = 1.18).

The external body color is bright yellow in life and there are no bands or other color patterns. Specimens preserved in ethanol fade to uniform cream. The head is short similar to other species of *Paryphantopsis* and the posterior of the foot is of average length for the genus.

The vas deferens is 0.2 the diameter of the slightly inflated head of the epiphallus which does not bear a diverticulum (Figure 11). The epiphallus is approximately 1.5 the length and 0.5 the diameter of the penis and widens only slightly at the junction with the penis. The penial retractor muscle is moderate in length, originating from the diaphragm and inserting at the basal 0.3 of the epiphallus. The penis is robust and of uniform width apically, narrowing basally to 1.2 the width of the atrium just before their junction. The atrium narrows slightly and then broadens between the vagina and gonopore. The vagina broadens slightly at its junction with the free oviduct and spermathecal duct. The straight free oviduct is 0.5 the width of the spermathecal duct at their junction with the vagina. The spermathecal duct is relatively wide basally, tapering to 0.3 its basal diameter at its midpoint, and remaining narrow until the junction with the ovate spermatheca.

The central teeth of the radula (Figure 12, middle row) are tricuspid, 8–9  $\mu\text{m}$  wide, and 12–13  $\mu\text{m}$  long, of similar shape and length but slightly narrower and shorter than the first lateral teeth, 10–11  $\mu\text{m}$  wide and 14–15  $\mu\text{m}$  long (Figure 12). The mesocones of the central and first lateral teeth are tall, slender, and project slightly beyond their basal plates. The ectocones of the central teeth are trigonal and symmetric. Ectocones and endocones of the lateral teeth are trigonal and about 0.5 the height of the mesocones. The endocones of the lateral teeth are slightly larger but otherwise of similar shape to their ectocones. The first 10 teeth to the left and right of the central row are similar to the first laterals. The next 3 on either side grade in shape and are difficult to classify as either lateral or marginal teeth. The last 4 marginal teeth are slightly wider, about 11–12  $\mu\text{m}$  wide, and shorter, 7–10  $\mu\text{m}$  long (Figure 13). The base of the unicuspid or bicuspid endocones of the first and second marginal teeth is reduced, and they originate from the side of their mesocones. The ectocones are reduced, and their rectangular bases are usually devoid of cusps. The

third and fourth marginal teeth often lack all cusps and are reduced to rectangular bases.

**Remarks:** The only other *Paryphantopsis* species with shells that have periostracal extensions on the growth lines and no processes at the margin are: *P. arcuata* Jutting, 1964; *P. dauloensis* Solem, 1970; *P. filosa* Jutting, 1964; *P. koragai* Slapcinsky, 2005; *P. latior* Jutting, 1964; *P. matawanensis* Slapcinsky, 2005; *P. platycephala* Jutting, 1964; and *P. pygmaea* (Bavay, 1908). *Paryphantopsis fragilicosta* is larger than *P. filosa*, is less depressed than *P. dauloensis*, has a higher spire than *P. latior* and *P. platycephala*, and has stronger spiral sculpture than *P. pygmaea* and *P. arcuata*. *Paryphantopsis fragilicosta* lacks an apical diverticulum, unlike all *Paryphantopsis* species for which the genital anatomy is known, except for *P. louisadarum*, *P. misimensis*, and *P. vanatinensis*, which are much larger, as well as *P. lebasii* and *P. yawii*, which have long periostracal processes. The ectocones of the marginal teeth of *P. fragilicosta* sit on a rectangular extension of the tooth, unlike all other *Paryphantopsis* for which the radular morphology is known other than *P. corolla* and *P. nucella*. It differs from these species by having very few or no cusps on the marginal teeth.

**Etymology:** The species name derives from the combination of the Latin adjective *fragilis* meaning crackling or easily broken and the feminine noun *costa* meaning rib, and refers to the shells fragile periostracal extensions.

*Paryphantopsis nucella* new species  
(Figures 14–19, Table 1)

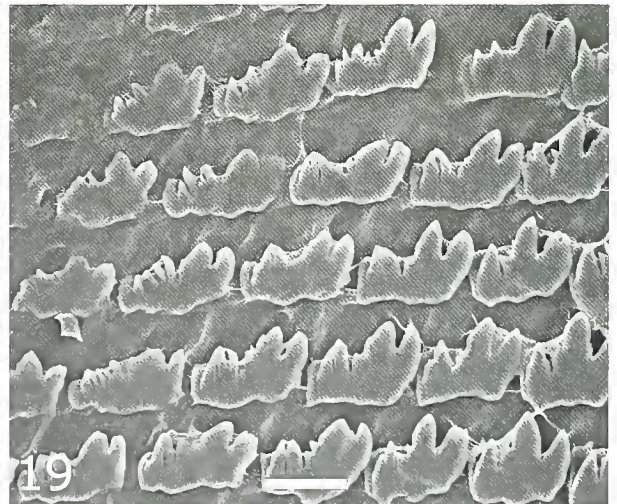
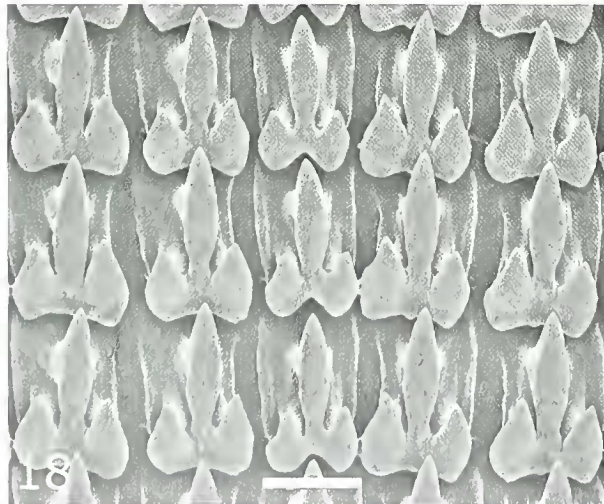
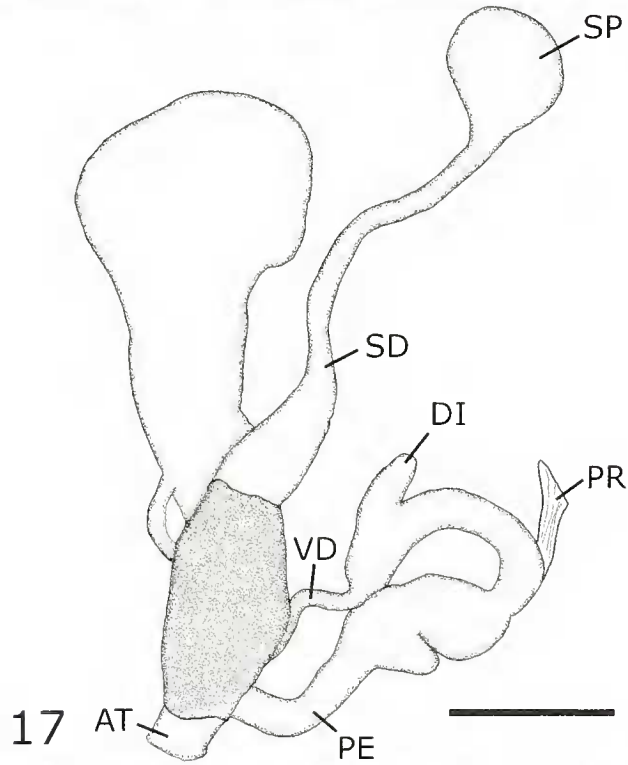
**Holotype:** UF 383996, J. Slapcinsky, 28 February 2005.

**Paratypes:** Papua New Guinea, East New Britain Province, New Britain: BPBM 282462 (2 specimens), MNIIW MP 1001 (2 specimens), PNGNM (2 specimens), SMF 329401 (2 specimens) UF 383993 (34 specimens), UF 383994 (3 specimens), type locality, J. Slapcinsky, 28 February, 2005; UF 366504 (5 specimens), UF 366506 (7 specimens), 12 km northwest of Marmar Village on the trail to Pakia Village, 5.432° S, 151.460° E, 900 meters altitude, J. Slapcinsky, 25 February 2005

**Type Locality:** Papua New Guinea, East New Britain Province, New Britain, Saukale, 13 km northwest of Marmar Village on trail to Pakia Village, 5.426° S, 151.453° E, 910 meters altitude (Figure 1).

**Habitat:** Collected in mixed hill forest on vegetation within 1 meter of the ground.

**Description:** The adult shell is globose to depressed-globose, average for the genus, 4.9–5.7 mm (mean = 5.22, see Table 1 for sample size and standard deviation) in diameter and 3.1–4.1 mm (mean = 3.75) in height, with 2.6–2.9 (mean = 2.81) rapidly expanding whorls (Figures 14–16). The apical surface of the shell whorls



Figures 14–19. *Paryphantopsis nucella*. 14–16. Shell. Holotype UF 383996. Scale bar = 1 mm. 17. Genitalia, UF 383993. Scale bar = 1 mm. 18–19. SEMs of radula, UF 383993. 18. Central and lateral teeth. 19. Marginal teeth. Scale bars = 10  $\mu$ m.



are flattened between the deeply impressed sutures and the submedian shell periphery, which gives the shell a somewhat angular appearance. The spire is slightly elevated, 0.1–0.2 mm (mean = 0.18). The teleoconch whorls descend slowly and regularly until the end of the body whorl and more rapidly near the aperture. Shell height:diameter ratio is 0.62–0.78 (mean = 0.72). There are 1.5 evenly rounded protoconch whorls sculptured with spiral rows of small pits. Approximately 14 rows can be seen on the apex of shells. These pits become elongated on the teleoconch whorls nearly fusing to form weak incised spiral striae. Spiral striae weaken, becoming obsolete on the final 0.30 of the body whorl where shell sculpture becomes predominated by growth lines all of which are accentuated with short periostracal extensions that do not bear peripheral processes. The protoconch is white, and teleoconch whorls gradually darken from yellow brown to brown. The umbilicus is closed by a reflection of the peristome. The aperture is ovate except for the flattened apical surface and has an aperture:width to aperture:height ratio of 0.94–1.25 (mean = 1.14).

The external body color is bright yellow in life and there are no bands or other color patterns. Specimens preserved in ethanol fade to uniform cream. The head is short similar to other species of *Paryphantopsis* and the posterior of the foot is slightly shorter than average for the genus.

The vas deferens is 0.2 the diameter of the head of the epiphallus, which bears an apical diverticulum that is approximately 0.3 the length and 0.7 the diameter of the midpoint of the epiphallus (Figure 17). The apical 0.7 of the epiphallus is uniform in diameter; the basal 0.3 is ovoid and twice as wide. The penial retractor muscle is moderate in length originating from the diaphragm and inserting 0.6 the way to the base of the epiphallus. The penis is 0.7 the length of the epiphallus. Its apical 0.3 is as robust as the base of the epiphallus and narrows rapidly basally. The basal 0.7 of the penis is 0.3 narrower than the apex and uniform in diameter to the junction with the atrium. The atrium is 1.5 times wider than the penis at their junction and remains constant in diameter to the gonopore. The vagina expands slightly at the junction with the free oviduct and spermathecal duct. The free oviduct is broad, not folded, and approximately the same diameter as the base of the spermathecal duct. The basal 0.3 of the spermathecal duct is wide and surrounded by darkly pigmented glandular tissue. The basal 0.5 of the spermathecal duct tapers apically to 0.2 of its original diameter and remains narrow until the junction with the ovate spermatheca.

The central teeth of the radula (Figure 18, middle row) are tricuspid, 10–11  $\mu\text{m}$  wide and 14–15  $\mu\text{m}$  long, and of similar shape and length, but are slightly narrower and shorter than the first lateral teeth, 11–12  $\mu\text{m}$  wide and 16–17  $\mu\text{m}$  long (Figure 18). The mesocones of the central and first lateral teeth are tall and slender, and project beyond their basal plates. The ectocones of the central teeth are trigonal and symmetrical. Ectocones

and endocones of the lateral teeth are trigonal and about 0.5 the height of the mesocones. The endocones of the lateral teeth are slightly larger but otherwise of similar shape to their ectocones. The first 12 teeth on either side of the central row are similar to the first laterals. The next three on either side grade in shape and are difficult to classify as either laterals or marginals. The last four teeth are clearly marginals and are irregularly multicuspoid, wider, about 13–14  $\mu\text{m}$  wide, and shorter, 8–9  $\mu\text{m}$  long (Figure 19). The endocones are as tall as the mesocones and are usually unicuspid, but sometimes bear 2 or 3 cusps. The ectocones sit on a rectangular base and are usually divided into 2–6 cusps that are 0.6 to 0.7 the height of the mesocones.

**Remarks:** *Paryphantopsis nucella* is similar to only *P. koragae* in having short periostracal extensions on all growth lines; these growth lines do not bear processes at the shell periphery. The shell of *P. koragae*, however, differs in having the shell periphery above, rather than below, the midpoint of the whorl. *Paryphantopsis nucella* is unique among *Paryphantopsis*, for which the genital anatomy is known, in having a large glandular area on the base of the spermatheca and having both an apically robust penis and a basally robust epiphallus. The ectocones of the marginal teeth sit on a rectangular extension of the tooth, unlike all other *Paryphantopsis* for which the radular morphology is known other than *P. corolla* and *P. fragilicosta*.

**Etymology:** The species name derives from the Latin feminine noun *nucella* and describes the shells resemblance to a small nut.

**Discussion and Conclusions:** Despite previous intensive surveys for terrestrial snails in coastal New Britain, much of the diversity of the island's interior mountains may remain to be described. More exploration is clearly needed in the Nakanai Mountains, where uplifted karst terrain has promoted the development of a unique and diverse snail fauna. Our cursory surveys, which did not penetrate deeply into, or reach high elevations in the Nakanai Mountains, uncovered several previously unreported species, including the three *Paryphantopsis* species described here. Most species of *Paryphantopsis* appear to be restricted to single mountain ranges or islands. The absence of these three species from relatively intensively surveyed coastal areas suggest they are endemic to the Nakanai Mountains. It is likely that other endemic species will be found in the Whiteman, Banning, and Willaumez ranges of New Britain. The Charopidae were until recently, considered a minor component of the terrestrial mollusk fauna of New Guinea (Solem, 1983). Our surveys (Slapcinsky, 2005; 2006) suggest charopid species radiations on New Guinea and surrounding islands rival the spectacular radiations exhibited by this family in the oceanic Pacific (Solem, 1983).

Based on shell and genital morphology, the relationships among the three *Paryphantopsis* species on New Britain are unclear. *Paryphantopsis corolla* and *P. nu-*



*cella* share several unusual traits that may indicate a common origin. In both species, the marginal ectocones are divided into numerous irregular cusps, the base of the epiphallus is robust, and an apical diverticulum is present on the epiphallus. *Paryphantopsis fragilicosta*, on the other hand, lacks these characters but has a large, globose shell that can be difficult to differentiate from that of *P. nucella*. However, all three New Britain species share unique rectangular bases to their marginal teeth, a possible synapomorphy. If so, characters that have been historically used to determine monophyly, i.e. genital and shell morphology, appear to be rapidly evolving and variable in this group. Additional morphologic and genetic characters are necessary before a clear picture of the relationships between *Paryphantopsis* species within New Britain and the adjacent New Guinea mainland can be resolved.

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#### LITERATURE CITED

Audra, P., S. E. Lauritzen, and P. Rochette. 2001. L'hyperkarst des montagnes Nakanai. Modèle d'évolution d'un réseau juvénile (gouffre Muruk) basé sur des datations U/Th et paléomagnétiques des sédiments. 93–99 in Audra, P., P. DeConinck, and J.-P. Sommier, (eds.) Nakanai 1975–1995: 20 ans d'exploration. Association Hémisphère Sud, Antibes, 224 p.

- Bavay, A. 1908. Mollusques terrestres et fluviatiles. Nova Guinea. Zoology 5: 269–292, pl. 14.
- Beehler, B. M. (ed.) 1993. A biodiversity analysis for Papua New Guinea. Papua New Guinea conservation needs assessment. Vol. 2. Biodiversity Support Program, Washington, DC & Department of Environment and Conservation, Boroko, Papua New Guinea, 1–433 p.
- Coeu, G. S. 1922. Descrizione di nuove specie di molluschi del Museo Civico di Genova. Annali del Museo Civico di Storia Naturale, Genova 9(3): 359–363.
- Flannery, T. F. 1995. Mammals of New Guinea. Cornell University Press, Ithaca, 568 pp.
- Fulton, H. C. 1902. Descriptions of new species of land Mollusca from New Guinea. Annals and Magazine of Natural History 7(9): 182–184.
- Jutting, W. S. S. v. B. 1964. Non-marine Mollusca of West New Guinea. Part 3, Pulmonata, I. Nova Guinea, Zoology 26: 1–74, pls. 1–2.
- McAlpine, J. R. and Fryne, D. E. 2001. Land use change and intensification in Papua New Guinea 1975–1996. Asia Pacific Viewpoint 42(2/3): 209–218.
- Orenstein, R. I. 1976. Birds of the Plesyumi Area, Central New Britain. The Condor, Vol. 78(3): 370–374.
- Pajmans, K. 1976. Vegetation. In: Pajmans, K. (ed.) New Guinea Vegetation, Australia National University Press, Canberra, 212 pp.
- Rensch, I. 1934. Systematische und tiergeographische Untersuchungen über die Landschneckenfauna des Bismarck-Archipels. I. Archiv für Naturgeschichte 3(3): 445–488.
- Rensch, I. 1937. Systematische und tiergeographische Untersuchungen über die Landschneckenfauna des Bismarck-Archipels. II. Archiv für Naturgeschichte 6(3): 526–644.
- Slapcinsky, J. 2005. Six new species of *Paryphantopsis* (Gastropoda: Pulmonata: Charopidae) from the Papuan Peninsula of New Guinea. The Nautilus 119: 27–42.
- Slapcinsky, J. 2006. *Paryphantopsis* (Gastropoda: Pulmonata: Charopidae) from the Louisiade Archipelago of New Guinea. The Nautilus 120: 119–130.
- Solem, A. G. 1959. On the family position of some Palau, New Guinea, and Queensland land snails. Archiv für Molluskenkunde 88: 151–158 pls. 12, 13, 2 figs.
- Solem, A. G. 1970. The Endodontid land snail genera *Pilsbrycharopa* and *Paryphantopsis* (Mollusca: Pulmonata). The Veliger 12: 239–264.
- Solem, A. G. 1983. Endodontoid land snails from Pacific Islands (Mollusca: Pulmonata: Sigmurethra). Part II, Families Punctidae and Charopidae, Zoogeography. Field Museum of Natural History, Chicago, ix + 336 pp.
- Thiele, J. 1928. Mollusken vom Bismarck-Archipel, von Neu Guinea und Nachbar-Inseln. Zoologische Jahrbücher 55: 119–146.
- Woodhead, J. D., S. M. Eggins, and R. W. Johnson. 1998. Magma genesis in the New Britain Island Arc: Further insights into melting and mass transfer processes. Journal of Petrology 39: 1641–1668.